UNIVERSITY DEPARTMENT OF ZOOLOGY
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SYNOPSIS FOR Ph.D.

Topic:-

Studies on the ecology and biodiversity of butterflies (Insecta: Lepidoptera) belonging to families Papilionidae, Nymphalidae, and Pieridae in Patratu and Ranchi

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State of the Art: -

Lepidoptera is the second largest order of the class insecta including moths (Heterocera) and butterflies (Rhopalocera). Order Lepidoptera is ecologically important in serving as insect pollinators includes both butterflies and moths. Butterflies serve as pollinators gather nectar and one of the important food chain components of the birds, reptiles, spiders and predatory insects. Butterflies are sensitive to various environmental factors such as changes in temperature, humidity, vegetation cover, rainfall etc. Any change in these factors directly affects the diversity of the butterflies in that area showing that they are most sensitive ecological indicators. The study locations were previously covered with dense vegetation but now they are under rapid anthropogenic activities resulting in huge impact on butterflies. Since in the past no such research work in these locations carried out making a correlation of diversity with climatic factors. This work will be beneficial in finding butterfly faunal diversity and its impact on food chain and ecosystem.

These winged organism's seasonal migration patterns and preferences for specific habitats show that they depend on certain environmental factors in order to survive. Consequently, it is important to regularly update assays of butterfly populations in order to uncover species variety and distribution patterns that may shed light on the population status of these diverse species and pave the way for future conservation research.

A rising city's ability to conserve and plan its environment effectively depends in a significant way on the mathematical computation of biodiversity indices, which measure ecological diversity. Since biodiversity shows that many butterfly species may find a suitable home in subtropical urban metropolis environments, it has been acknowledged as one of the essential elements of environmental sustainability. In order to meet the increased globalization pressure of better infrastructure along with its local biodiversity. By collaborating with the Forest Department and encouraging the planting of larval feeding plants of the butterfly species alongside roadway pavement, the local conservation organizations can play a significant role. Raising citizens' awareness would contribute to an urban area's regional biodiversity richness being improved.

The study area is home to a diverse range of plants that offer the perfect nesting habitat for the region's vast diversity of butterflies. This study aims to demonstrate the value of a local area as a model geographical region with a variety of ecosystems, highlighting the significance of the local community in long-term research on biodiversity and conservation efforts. It is crucial to comprehend how dependent each species of butterfly is on its natural habitat. Taking these associations into account could aid in curbing the declining butterfly population brought on by increasing urbanization and habitat degradation.

Additional research on this region's native butterflies, along with those butterfly species that are listed under Red IUCN data, may encompass a range of other topics and would surely go a long way towards resolving the worldwide problems of nature preservation and the decline of its species.

Approximately 17,280 species of butterflies are found worldwide, comprising taxa that have been described but not yet synonymized. These species are presently organized into 1855 genera, 35 subfamilies and 7 families. Of all the lepidopteran species, butterflies make up only 9–12% (Oakley Shields, 1989). As one of the most researched and well-known insect groups, butterflies are also considered the flagship species. Being both pollinators and energy transferors, they are regarded as one of the most suitable taxonomic groups for assessing the environment. They are also a vital component of any natural ecosystem. According to research on biodiversity, butterflies are regarded as the "flagship of taxa" among insects (New, 2009). In total 18,768 butterfly species have been identified worldwide (Van Nieukerken et al., 2011).

In addition to being visually pleasing, they are effective pollinators. Butterflies are delicate organisms that react very quickly to changes in their surroundings. Moths and butterflies are excellent subjects for research on population dynamics and community ecology. (Pollard, 1991). In all, 237 species were identified in the survey in the eastern part of upper Assam which form part of the Indo-Burma hotspot. Among these are thirty-three species that are legally protected under the Indian Wildlife (Protection) Act 1972 (Anonymous 1997), with two classified under Schedule I, 29 under Schedule II, and two under Schedule IV. The distribution of the 747 species that have been identified is limited to the eastern Himalaya and north-eastern India. (Singh, 2017)

According to current research, India's subcontinent is home to 1318 species, of which 89 are in the Papilionidae family, 277 are in the Hesperiidae family, 92 are in the Pieridae family, 19

are in the Riodinidae family, 380 are in the Lycaenidae family, and 461 are in the Nymphalidae family. (Cotton et al., 2015)

In the field study at combined campus of Zoological Survey of India, Botanical Survey of India and Anthropological Survey of India, Dehradun, Uttarakhand between November 2018 and March 2019 showed that there were 67 species in all, 46 genera organized into five families: Papilionidae, Pieridae, Nymphalidae, Lycaenidae, and Hesperiidae. The Nymphalidae family contained the greatest number of species (31), followed by the Pieridae family (11), the Papilionidae family (8 species), the Hesperiidae family (4 species), and the Lycaenidae family (13 species). Of these 67 species, an analysis of relative abundance showed that 28 were common (42%), 23 less common (23%), and the remaining 16 unusual (24%). (Sharma & Sharma, 2019)

A study conducted by (Mukherjee et al., 2015) in Kolkata Metropolitan Area (KMA) which covered urbanized Kolkata city and its surroundings suburban and rural areas showed 96 butterfly species. The family Lycaenidae recorded the highest number of butterfly species (31.25%), followed by the families Nymphalidae (28.13%), Hesperiidae (18.75%), Pieridae (12.50%), and Papilionidae (9.38%).

In the Rock Garden in Ranchi, Jharkhand, 76 butterfly species from 53 genera and 5 families were identified during a short-term survey conducted between December 7 and 10, 2023. These families include Papilionidae (2 genera, 7 species), Nymphalidae (23 genera, 34 species), Pieridae (12 genera, 16 species), Lycaenidae (11 genera, 14 species), and Hesperidae (5 genera, 5 species). The family Nymphalidae had the highest Shannon diversity score (H'=2.96), while the family Hesperidae had the lowest (H'=1.49). An inverse tendency was observed in Simpson's diversity index (Ds). The butterfly community in this study region had a significant degree of diversity, as demonstrated by the several diversity indices. (Das et al., 2023)

A total of 65 distinct butterfly species were identified on the campus of Dibrugarh University, Assam of North-East India based on the thorough study. The majority of the butterflies that were observed belonged to the 26 species from 21 genera in the family Nymphalidae, it was discovered. The remaining species included 12 from 7 genera in the Pieridae, 11 from 11 distinct genera in the Hesperiidae, 7 from 3 genera in the Papillionidae, and 8 from 8 different genera in the Lycaenidae showing dominance of Nymphalidae family. Seasonal differences were also noted across the species of butterflies with most abundance in Monsoon season. (Dutta & Puzari, 2020)

The use of herbicides, insecticides, and genetically engineered crops is also causing a decline in the number of butterflies in the population. The caterpillars of butterflies are extremely sensitive to the plants that serve as their hosts, and as such, they are a symbol of bio-diversity, individuality, and ecological components. Butterfly populations are also at risk due to genetic engineering's alteration of host plants, which results in the loss of those plants. One of the biggest threats to butterflies is habitat loss, which is correlated with rising rates of industrialization and urbanization. However, these lovely insects are in danger of going extinct and are fighting for their survival as a result of the development of industrialization and urbanization. (Sharma & Sharma, 2019)

Many creatures, including birds, reptiles, amphibians, and others, eat butterflies, although occasionally ants and scorpions may eat caterpillars. Certain flies' and wasps' eggs reside inside the body of the caterpillar as parasites and feed on it. The population of birds, mice and other creatures that depend on butterfly populations for sustenance will likewise decline if butterfly populations decline. The ecosystem as a whole will collapse due to this loss. "Birds schedule their entire breeding season around the times when caterpillars will be most plentiful." Less food for developing chicks will be available if the population of caterpillars and butterflies declines. (Mobeen et al., 2016)

With 13 species, the family Nymphalidae had the most species variety of all the 40 species of butterflies that were identified. The monsoon season was determined to have the maximum species richness, while Aravalli Biodiversity Park in New Delhi had the highest biodiversity index out of the six study locations. Previous research has focused mostly on the naming and documenting of species, with little attention paid to quantitative interpretations of rising urbanization through biodiversity indices. The results of this study show how important green spaces are to the urban infrastructure of cities in order to sustain a variety of butterflies.(Paul & Sultana, 2020).

In and around Kolkata, 96 butterfly species belonging to five families were observed throughout the course of this study. According to the average number of butterfly species found in each of the three sites, 12.50% of species were classified as very common, whilst 31.25% of species were common, 25% were not rare, 22.92% were rare, and 9.38% were extremely rare. (Mukherjee et al., 2015).

A study conducted to evaluate the variety of butterfly species in Bhubaneswar, India, using that area as a model to comprehend the biology and dynamics of the local population. In all, 107 species of butterflies were identified in this study, representing 76 genera and five families (Papilionidae, Hesperiidae, Pieridae, Lycaenidae, and Nymphalidae). No butterflies from the families Hedylidae or Riodinidae were observed during this investigation. Nine of the total species are protected legally in India under the WPA, 1972, while 17 of the species are new to the city's records. (Samal et al., 2021) .

The Nagarahole National Park (NNP) has records for 138 butterfly species, representing five different lepidopteron families. Out of these, 113 species were prevalent throughout all forest ranges in the NNP. The Shannon 'H' and Simpson 'J' indices of evenness for every butterfly species found, with the exception of 25 butterfly species that showed habitat specificity. Further, the Shannon diversity index was 4.49 to 4.59 with good Fisher alpha value and Sorenson's Index. As a result, the biodiversity profile revealed a usual declining trend and a strong butterfly diversity profile within the NNP. In protected natural settings, the presence of butterflies is crucial for pollinating many plant species. (Basavarajappa et al., 2018)

There have been reports of 702 individual butterflies from 21 species in the families Nymphalidae, Pieridae, and Papillonidae, along with their host plants during a study in Kanke, Ranchi, Jharkhand . The family Nymphalidae held the most dominance. The Shannon Weiner Index was used to calculate the diversity (H). The year 2021 was discovered to have the highest computed Shannon Weiner diversity index (H) value of (3.012). These numbers suggest that there is a good diversity of butterflies in the research area and that it may contribute to the preservation of biodiversity. (K. Kumari & Thakur, 2022)

The range of sorts of butterflies belonging to the three species mentioned in the work was indicated by the butterfly survey conducted at Kanke, Ranchi. Records included 13 species of butterflies from the family Nymphalidae, 4 species from the Pyridae family, and 4 species from the Papilionidae family. The variety of butterflies is abundant in the Kanke area of Ranchi. The findings unmistakably showed that the Nymphiladae family had a greater species richness than the Pieridae and Papillionidae families. The variety of butterflies was abundant in the around Kanke of Ranchi city. (K. Kumari et al., 2021)

A report on butterfly diversity of Biodiversity Park Ranchi, Jharkhand, India shows 88 butterfly species, spread across 62 genera and five families, were identified in the current study. Hesperiidae (eleven genera, twelve species), Papilionidae (four genera, twelve species), Nymphalidae (seven genera, twenty-six species), Pieridae (seven genera, nine species), and Lycaenidae (twenty-three genera, twenty-nine species) are among the families. The most common taxa were discovered to be Lycaenidae (33%) and Nymphalidae (29%) as well as Hesperiidae (14%), Papilionidae (14%), and Pieridae (10%). The percentage of Butterfly families that exist is displayed. All families of butterflies, with the exception of Hesperiidae, were found to be most frequently encountered between April and August. But from June to October, the Hesperiidae family was primarily noticed. (N. Kumari et al., 2023)

From above review of literature it can be inferred that India is rich in butterfly diversity with dominance of some families of butterflies. Also various studies conducted in different locations of Jharkhand shows its richness in biodiversity of butterfly species. These findings will help to continue further research in these proposed locations.

From the review of the literatures, it can be inferred that Jharkhand and its various surveyed locations are rich in butterfly biodiversity. There are some untouched locations such as Patratu, which will be surveyed in this project and compared with previously studied locations around Jharkhand such as Ranchi to obtain appropriate outcomes. Patratu has relatively little urbanization and many natural resources. Ecological factors have a significant impact on butterfly diversity. This project will be concerned mainly with data collection about the diversity of butterflies in the proposed sites with the use of various statistical tools such as the Shannon-Weiner index, Simpson’s dominance index, Jaccard’s similarity index, and many more. Data analysis will be done with the help of various modern AI tools, which can help interpret results obtained in the maximum possible ways. Surveying a location with little information about butterfly diversity will help gather data that will help in further scientific studies. There might be some new species that will be identified during this study. A recent study from September 2021 to July 2023 on the diversity of butterflies in Jharkhand's Ranchi area was conducted in which 156 species in all were discovered during the investigation (N. Kumari et al., 2024). These results established a baseline data on the butterfly checklist helping further scientific investigation and developing conservation strategies.

Problems to be Investigated :

(a) Analyzing the ecology and biodiversity of butterflies (Lepidoptera: Rhopalocera) from various locations in and around Patratu and Ranchi, including parks, gardens, and areas nearby dams or horticulture and floriculture sites, etc.

(b) Study of various ecological factors with their influence on abundance, diversity, and species richness of the particular location.

(c) Identification of their position in IUCN Red Data List along with survey, collection and Preservation of these identified butterfly species.

(d) Identification of major threats to their biodiversity in Patratu and Ranchi.

Objective of the Investigation: -

(a) Survey, collection, identification, and preservation of different collected species.

(b) Study of population diversity, species richness in the collection areas.

(c) Tabulation of climatic factors and their effect on butterfly diversity.

(d) Comparative analysis of diversity in the selected study locations.

Motivation:

Rapid changes in climatic factors such as temperature, humidity, pressure, etc. have a significant impact on the biodiversity of butterflies. As they are important pollinators and connective links in the food web, their loss in the economy will have an unbeatable impact on the environment. Insecticides are used recklessly and widely, which kills them destroying the ecology and environment. Therefore, an account of the biodiversity of butterflies and their distribution must be there to make significant changes that might help to conserve them.

Hypothesis:

Among the most important ecological indicators are butterflies. Loss of habitat, increasing urbanization, increased temperature, and change in humidity levels due to both natural and anthropogenic activity could all have an impact. One of the largest cities in eastern India that is seeing urban development is Ranchi. Patratu is rich in vegetation with very little urbanization.

Significant effect of the ecological factors on the diversity of butterflies. The goal of the current project is to learn about migratory and endangered species as well as the effects of climatic factors on their diversity and richness. A comparative analysis of the two study locations will yield important findings that will influence future investigations. Ecology is hypothesized to have an impact on butterfly biodiversity.

Research Design and Methodology:

Study area – The proposed study sites are located in various places of Patratu and Ranchi, Jharkhand, India. They are located in the eastern section of the Deccan plateau and southern section of the Chota Nagpur plateau, Jharkhand of eastern part of India. The topography is hilly with dense tropical forests. This Forest Divisions have Sal trees (*Shorea robusta*) as the dominant tree species. The average rainfall of the study sites is marginal.

Tools to be used in the collection of data:

(a) Collection of the butterfly species by Aerial Netting Method. (Martin, 1977)

(b) Site assessment shall be made by the method detailed by Pollard, 1991 and others.

(c) Statistical Analysis :-

(i) Shannon-Weiner index for species diversity to observe the population ecology. (Shannon, 1948).

$$H' = -\Sigma\, p_i \ln p_i$$

Where,

H' = Shannon- Weiner index

$p_i = \frac{n}{N}$

n= number of individuals in particular species

N= total number of individuals of all species

ln= the natural logarithm

(ii) Simpson's dominance index - This index used to measure the proportion of more common species in a community and it can be calculated using the following mathematical formula. (Simpson, 1964)

$$(Ds) = \sum_{i=1}^{s} [n_i (n_i-1)/N (N-1)] \text{ or } (Ds)= \sum_{i=1}^{s}(\frac{n_i}{N})^2$$

Where,

Ds= Simpson's dominance index

S= number of species in a community

n_i= number of individual in i^{th} species

N= total number of individual in all species

(iii) Jaccard's similarity index of different sites. (Stiling, 2002)

$$C_j = \frac{a}{(a+b+c)}$$

Where,

a= the number of species common to both sites

b= the number of species in site B, but not in A

c= the number of species in site A, but not in B

(iv) Pearson's Correlation - (Stiling, 2002)

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{[N\sum x^2 - (\sum x)^2]\ [N\sum y^2 - (\sum y)^2]}}$$

Where

N= the number of pairs of scores

∑x= the sum of x scores

∑y= the sum of y scores

∑xy= the sum of products of paired scores

$\sum x^2$= the sum of squared x scores

$\sum y^2$= the sum of squared y scores

(d) Identification – it involves the use of keys available in the Zoological Survey of India, A synoptic catalog of the butterflies of India (Cotton et al., 2015),(Van Nieukerken et al., 2011), (Kunte et al., 2024), (Evans, 1932), Online identification tools, etc.

(e) Data Analysis - Data Analysis will be done with the help of MS-Excel, PAST software, and other software so that accurate results can be obtained and analyzed to find suitable relationships among results.

(f) Various other tools such as GPS Devices, types of cameras, and other highly advanced research equipment.

(g) Some AI based technology e.g e-butterfly app, etc shall be used as per the need.

Significance of the study:

(a) The purpose of analyzing the diversity of butterflies along the urban-rural gradient was to infer how spatial factors affected the aggregation of different butterfly species throughout the urban landscape.

(b) The results of the study are expected to supplement the necessary information on conservation management and enhancing the ecological roles of the butterfly species in study sites in India and similar geographical areas.

(c) The loss of habitat and changes in the environment pose a hazard to butterflies. The life cycle may be impacted by pollution and urbanization. What beneficial or bad effects do man-made ecosystems have on their way of life? Additionally, an inventory of the butterflies gathered will be prepared as part of the current project.

Future Work:

(a) The results of this study will be helpful in developing long-term conservation plans for this fragmented forest patch, ensuring the preservation of the fauna of butterflies and the preservation of biodiversity and ecosystem integrity.

(b) There hasn't been much research done in the study region on how ecological factors affect Lepidoptera butterfly biodiversity. This project will assist in creating an inventory of butterflies

by identifying them, determining their distribution, examining their life cycle, and examining the effects of different ecological conditions and food plants.

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